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ABSTRACT

Methods of mathematics instruction adapted for mentally handicapped students are considered. Using three theories of J. Piaget--that children's mental capabilities increase with age, that their mental capabilities pass through fairly observable stages, that mentally retarded children take longer to pass from one stage to another--the author outlines eight principles of learning and instruction. An instructional format is provided which has the following five parts: presentation, exploration, integration, seatwork, and practice and enrichment. (PHR)

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TAILORING MATH INSTRUCTION TO CHILD DEVELOPMENT

by

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As our session leader, Mr. Doherty, indicated, I've been a professional educator for many years. I started in the Sputnik era of the fifties as a math and science teacher, later coordinated the program for mental retardation at the University of Missouri, and for the past five years have devoted my full-time efforts to curriculum development for math education.

There are many things that I would like to share with you during the next fifty minutes. Some of it will touch on theory, but for the most part I will focus on things directly related to classroom instruction.

Let me begin by sharing some of my concerns and biases. These, you may or may not agree with, but by providing them "up front", you will know where I'm coming from.

1. Jack Cawley of the University of Connecticut has expressed concern that arithmetic instruction for the mentally retarded is too frequently confined to the mechanical teaching of computation. I definitely share that concern. As we enter the age of the hand calculator, lengthy written computation may in time become some of the least essential skills in the arithmetic curriculum. One of the things I tried to do with the KeyMath test was to promote an awareness of the range of topics that need to be taught.
2. In relation to the first concern, I believe that many of the math performance characteristics researchers ascribed to the mentally retarded are a reflection of the instruction they have received and have little to do with the retarded's innate capacities and limitations.

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3. I worry about the current pressures of accountability, etc., that lead us toward easy-to-teach and easy-to-test bits of information. Such instruction is frequently fragmented and difficult to relate to the real world.
4. I also worry about the number of retarded youngsters who independently struggle to learn things when working independently is confused with individualization. This perplexing problem occurs frequently in mainstreaming situations, but is no small problem in many special education classes. Selected group experiences and individualization are not mutually exclusive.
5. In relation to the fourth concern, it is my perception that most retarded students learn minimally from worksheet exercises, except in those rare situations where the content has been extremely carefully programmed. I don't mean to imply that worksheet exercises don't have value, because they do--appropriate seatwork lets the child practice, review, and verify what he or she has initially learned. My point is that a threshold of initial learning had to occur first.

A retarded child tends to be an inefficient learner, particularly on an independent basis, and one who has frequently experienced too few academic successes to possess a strong motivation to want to learn. If the seatwork has new content, such a child is likely to quickly become frustrated, begin dawdling, daydreaming, etc., as he or she mentally withdraws from the situation. If the seatwork has content that is too easy, such a child may dutifully practice it until the cows come home--grateful that new concepts are not being introduced and learning is not required. When I see classroom math instruction which day in day out

features computation worksheets, I firmly believe that the teaching is geared to the convenience of the teacher and not geared to maximizing student learning.

Now let us briefly look at child development, learning, and theoretical bases for instruction. I doubt if there is a person in this room who isn't generally familiar with the work of Piaget. His thoughts were popular in the thirties and have experienced a tremendous rebirth of interest over the past two decades. I suggest we forever remember three messages from Piaget's many contributions:

1. Children are not miniature adults--a child's mental capabilities increase as the neural organization of his or her brain gradually becomes more complex. Thus, it is possible to confront a child with a concept or skill that he or she simply isn't equipped to handle.
2. As a child's neural organization increases in complexity, his or her mental capabilities pass through fairly observable stages--three of which let's discuss here:
 - From about a mental age of 1.5 to 7, the child's thought processes are tied closely to perceptions. "Seeing is believing" is the watch word of this pre-operational stage. The child generally has insufficient reasoning power to override impressions obtained from perceptions as evidenced by the many conservation-type experiments that have been conducted. For example, when a glass of water is poured into a larger container, the child may conclude that there is less water because the height of the water in the new container is lower. This example also illustrates the child's "present bound" orientation at the pre-operational stage when he or she will consistently draw conclusions without considering antecedent conditions. The child at this stage

also has difficulty determining relevant stimuli and is thus easily distracted.

- By about the mental age of seven, the child's reasoning powers advance to the point where he or she is no longer tied to perceptions.

During this concrete stage which extends to a mental age of about 11 years, the child's learning appears to have progressed to the point that he or she appears to enjoy and profit from interacting, structuring, and manipulating the environment.

- When a child attains a mental age of 11 or 12, he or she reaches the stage Piaget titled "formal operations". Now the child has accumulated sufficient background experiences to comfortably use symbolism and apply abstract reasoning. However, even when a child is functioning at this level, it is strongly recommended that new concepts and skills be introduced using concrete methodology before progressing to something as abstract as worksheet symbolism.

3. The mentally retarded child will take appreciably longer to pass from one stage to another and, depending on his or her capability, may never progress to the formal operations stage.

The work of Piaget and contemporaries such as Bruner, Dienes, Benoit, Guilford, and Gagne provide us many principles of learning and instruction. I'd like to share with you the eight that I find crucial and which form the foundation for the instructional approach and sample lessons we will discuss later. In doing so, let me note the chief proponents of each principle.

Learning:

1. Moves from the concrete to the abstract. (Piaget, Bruner)
2. Is enhanced by active participation. (Hebb, Benoit)
3. Is verbally mediated. (Bruner)

4. Should involve multiple thought processes. (Guilford)
5. Should be paced with new concepts related to old. (Gagne)
6. Is enhanced through the multiple embodiment of concepts. (Dienes)
7. Requires diversified practice and self-verification. (Piaget)
8. Is an individual experience which can be enhanced through effective group activity. (Gibb)

I could be persuaded to add a ninth principle of instruction which I think is particularly applicable to teaching the retarded who are frequently short on personal academic motivation. This relates to Zigler's work showing teacher enthusiasm as a positive reinforcer and Rosenthal's work which shows that the absence of positive expectancy by the teacher is a powerful deterrent to learning. Thus, I would suggest that teacher enthusiasm is contagious.

Instruction that follows these principles has very observable characteristics. It possesses continuity, relates new learning to old, involves the teacher at critical times, and provides variety--in terms of groupings, in matter and in terms of student response modes. Such instruction also features short/meaningful explanations and practice sessions, a mix of active and passive activities, has the student personalize experiences by doing and explaining, and provides frequent benchmarks and achievement goals enabling close monitoring of the student's performance and the instruction.

Describing such instruction is easy; providing it is a whole lot harder. Such a description, however, is invaluable because it gives you a target to strive for.

The instructional format I suggest involves extended lessons, each of which has five parts: Presentation, Exploration, Integration, Seatwork, and Enrichment and Practice.

Each of these parts may involve one or more activities and an indefinite amount of time. The time devoted to an extended lesson is determined by accomplishments. Thus, some lessons may be completed in a period and some may extend over two or more days depending on the student's ability and the difficulty of the concept.

Presentation activities are large group activities which are designed to:

- introduce the concept or skill
- introduce any new terminology
- relate the new learning to old.

Such activities frequently involve teacher and volunteer demonstrations. When feasible, all students are given an opportunity to actively participate. These activities should incorporate a dialog between the teacher and students to help the teacher identify how quickly the students are assimilating the concept or skill and to help the students identify with the concept or skill.

Exploration activities are generally small group and individual activities which are designed to:

- encourage student use of concrete and pictorial aids as they represent and apply the concept or skill in different ways
- provide students with an opportunity to practice applying the concept or skill in group situations before being required to apply it independently.

Integration activities are discussion-based activities led by the teacher. They are designed to:

- review the concept or skill
- suggest practical uses and applications for the concept or skill.

Seatwork activities have the student independently completing worksheets to demonstrate what he has learned. This component:

- provides independent practice
- provides verification--making both the student and the teacher aware of how much of the concept or skill the student has assimilated.

Enrichment and Practice are follow-up activities in which the teacher may involve the students on a selective basis. Their intent is to provide individual and group experiences that promote:

- drill
- extensions
- applications.

In order for the instructional format I described to work, the teacher must be an active participant. He or she must be skilled in differential questioning, must be able to establish routine classroom procedures for getting into and out of groups that occasionally vary in terms of size and composition, and must be able to provide groups and individuals with clear-cut goals and tasks that they are able to accomplish.

The instructional format I have described makes two assumptions:

1. That extended lessons will be clustered with review activities and a test to follow each cluster.
2. That the concepts and skills to be taught have been carefully identified, clustered, and sequenced. The sequencing should follow a general spiral with a progression which flows from concepts to skills to applications and then repeats. For example, when students have acquired numeration concepts 0-9 and can rational count, they should progress to adding and subtracting at this level and then applying such numbers

in beginning measurement, etc. The cycle is then repeated starting back in numeration with the study of larger numbers.

The extended lessons and instructional format I've described is for use in classrooms where the students functioning at fairly similar levels or can be separated into a couple of sections where youngsters functioning at similar levels can be taught math at different periods in the day. The instruction is not a diagnostic/remediation approach; rather, it is an attempt to make instruction developmental, success-oriented and, hopefully, preclude or reduce the need for the latter approach. It is an approach that you can establish in your classroom using a compilation of teacher-made and available materials.

I have been working for several years to develop a complete program based on this approach. The program itself is still in refinement. I have, however, brought along a couple of extended lessons we call stages as examples of the instructional approach I have been describing. First, let's look at a stage that has as its objective the introduction of ordinal numbers. Prior stages in the program sequence provide the concepts and skills listed in the prerequisites. In a moment, this stage will be disseminated. As you look at the activities, please note:

1. That the teacher's talk is provided as a sample, the teacher is not expected to parrot.
2. The variety of experiences which involve student demonstrations and work with manipulatives, pictorial materials, and worksheets.
3. That activities are open-ended and allow the teacher to be selective and take as much or as little time as is deemed necessary.

4. That the format provides multiple opportunity to break instruction for a period; thus, permitting the teacher to extend the instruction over two or more days as necessary while maintaining the continuity of the lesson. As you read, consider where you might take breaks.
5. How the general progression of responsibility for learning moves from the teacher to the group and then to the individual. The learner is not put on the spot until he or she has the background to make successful responses.

Next, let's quickly look at a time stage which has as its objective the sequencing of events in chronological order. This topic is perceived to be a basic concept that underscores the future use of a clock or a calendar. It does not have the manipulative involvement of the other stage because at this level none seemed directly applicable. The stage is included as a link to the time topics that will be addressed by the other presenters.

In closing, let me share some recommendations that are frequently made by math educators. They suggest that our math instruction make more and better use of materials, involve more discussion time spent on concept and skill development, and include short, specific practice sessions. In terms of skills, they urge greater attention to estimating, data collecting, and problem solving.

I thank you for your attention and will be happy to answer questions at the end of this meeting.

THE END